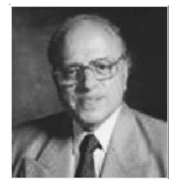
Norman Borlaug and a Hunger-Free World

M S Swaminathan



Mankombu Sambasivan Swaminathan is a geneticist who led India's "Green Revolution". He is the founder and Chairman of the M S Swaminathan Research Foundation and Treaty's Ambassador. His research interest involves a wide range of problems in basic and applied plant breeding, development and the conservation of natural resources.

Swami Vivekananda, whose 150th birth anniversary is being celebrated this year, used to say, "This life is short; its vanities are transient. He alone lives who lives for others". Norman Borlaug was one such person, who lived and worked for the cause of ensuring food for all. As a scientist, he helped to breed outstanding varieties of dwarf wheat, which could help to triple the average yield. As a humanist, he placed faces before figures, and helped to highlight the fact that the persistence of hunger, in the midst of opportunities to increase food production through synergy between technology and public policy, is inexcusable.

Dr Borlaug was not satisfied with scientific know-how alone. He wanted to convert scientific know-how into field level do - how. On the last day of his life, a scientist showed him a new equipment to trace soil fertility. Dr Borlaug's last words before his death were, "Take the tracer to the farmer". On the occasion of his birth centenary on March 25, 2014 we should all follow his advice and accelerate progress in linking the lab with land. His life and work will be eternal sources of inspiration and lead us to convert his vision of a hunger-free world into reality.

Borlaug's Approach to Increasing Wheat Yield

Born on 25 March 1914, Norman Borlaug had his early upbringing on an Iowa farm. Experience of deprivation and hardship during the early 1930s gave him a first-hand view of the ills of low farm productivity, poverty and hunger. After completing his PhD degree in plant pathology at the University of Minnesota in 1942, he joined the Rockefeller Foundation's agricultural programme in Mexico, which led to the birth of the International Maize and

Keywords
Norman Borlaug, *Norin 10* dwarfing gene, *DWGW* gene, green revolution, rice and wheat varieties.

Wheat Improvement Center (CIMMYT). There he began his work on wheat, with special emphasis on controlling the fungal disease called rust. He introduced a multipronged approach, including the development of composite varieties of wheat characterized by phenotypic identity but genotypic diversity in resisting different species of the pathogen.

Drawing on the availability of the *Norin 10*[1] dwarfing gene from Japan, Borlaug launched a programme in 1953 to breed semi-dwarf, high-yielding varieties of wheat that responded well to irrigation and fertilizers. Traditional wheat varieties are tall, and tend to topple over if grown in highly fertile soil. Conditions for good crop growth however, are also conducive to the spread of pathogens, so he intensified his research on combining high yield potential with disease resistance. Borlaug decided to adopt a 'shuttle' programme that involved growing different generations (F2, F3 and so on) under two diverse conditions – a summer crop in the cooler highlands near Mexico City and a winter crop in the warmer conditions of Sonora in northwest Mexico. This procedure led to the breeding of semi-dwarf, disease-resistant wheat strains with broad adaptation, such as Sonora 63, Sonora 64, Lerma Rojo 64 and Mayo 64. These varieties with a yield potential of 5–6 tonnes per hectare transformed in the 1960s wheat productivity in Mexico, followed by India and Pakistan. In 1966, in a strategy supported by Borlaug, India imported 18,000 tonnes of seeds of Lerma Rojo 64-A and a few other varieties from Mexico. The result was a jump in wheat production from 12 million tonnes in 1965 to 17 million tonnes in 1968. Similar results were obtained in rice, as a result of the introduction of the *Dee-gee-woo-gen* dwarfing gene[2] from China into tall varieties of *indica* rice at the International Rice Research Institute in the Philippines.

Green Revolution, *Norin 10* and the Dwarf Genes

The dwarf plant stature in the Mexican varieties developed by Borlaug as well as by others came from the Norin dwarfing gene identified by Gonziro Inazuka of the Norin Experiment Station,

[1] *Norin 10* plants are semi-dwarf wheat cultivar from experimental station in Iwate Prefecture, Japan. *Norin 10* is just 2 ft tall instead of four. *Norin 10* helped India and Pakistan to increase the productivity of crops during 'Green Revolution'.

[2] The *Dee-gee-woo-gen* rice plant was first identified in China and was characterized by its shorter height (~25% shorter compared to the parent it spontaneously originated from). Due to its non-lodging property, *DGWG* was used for breeding programme of high-yielding rice varieties, much as the way *Norin 10* variant was used for wheat breeding. The *DGWG* character was later attributed to a molecular change in *SEMI DWARF 1* (*SD1*), a gene that encodes a gibberellic acid biosynthetic enzyme, GA20ox.

Japan. The *Norin 10* dwarfing gene is also known in scientific literature as *Reduced height* (*Rht*) gene which may either be dominant or semi-dominant. Studies have shown that mutations in dwarfing genes lead to reduced sensitivity to the endogenous growth regulatory hormone gibberellins[3,4]. The semi-dominant mutant alleles *Rht-B1b* and *Rht-D1b* confer different grades of dwarfism. Thus the regulation of gibberellins is an important pathway for reducing plant height. In addition to Borlaug, Orville Vogel of Washington State University, US used the Rht gene effectively to breed the winter wheat Gaines, which held for a long time the world record for yield in wheat.

[3] Gibberellins, which are plant hormones consists of a group of diterpenoid acids that function as plant growth regulators. They play an essential role in various developmental processes, few of them being stem elongation, germination, dormancy and flowering.

[4] Peng *et al*, 'Green revolution' genes encode mutant gibberellins response modulators. *Nature*, Vol.400, pp.256–261, 1999.

This Green Revolution, a term coined in 1968 by William Gaud, remains an astonishing phenomenon that not only boosts productivity but also saves land resources. For example, in 2013 India produced 95 million tonnes of wheat from 26 million hectares of land. At pre-Green Revolution yield levels, 95 million hectares would have been needed.

In 1984, Borlaug accepted a part-time professorship at Texas A&M University, where for more than 15 years he taught a graduate course in international agriculture.

Influence of Borlaug's Research on 'World Food Crisis'

Borlaug's seminal research involved traditional breeding methods, but he was a great supporter of biotechnology research, including the use of recombinant DNA technology. He believed firmly in exploiting the new opportunities for creating novel genetic combinations to meet the challenges arising from climate change. He was also an advocate of 'public good' research, and argued for the free exchange of genetic material and the continuous development of germplasm by approaches such as hybridization between winter and spring wheats. In 2006, the Norman Borlaug Institute for International Agriculture was set up at Texas A&M to promote science-based solutions for the challenges facing global agriculture.

Norman Borlaug started his research career in agriculture in

Severe famine across the globe made Borlaug take a decision on the sustainability of small farms. In 1960, the introduction of Mexican semi-drawf varieties of wheat in India remarkably improved the feeding status.

Mexico at a time when the world was passing through a serious food crisis. During 1942–43, nearly 3 million people died of hunger during the great Bengal Famine. China also experienced widespread and severe famine during the 1950s. Famines were frequent in Ethiopia, the Sahelian region of Africa and many other parts of the developing world. It was in this background that Borlaug decided to look for a permanent solution to recurrent famines by harnessing science to increase the productivity, profitability and sustainability of small farms.

The work he did in Mexico during the 1950s in breeding semi-dwarf, rust-resistant wheat varieties and its extension to India, Pakistan and other countries during the 1960s brought about a total transformation in the possibility of achieving a balance between human numbers and the human capacity to produce food. Developing nations gained in self-confidence in their agricultural capability. He disproved the prophets of doom like Paul Paddock and William Paddock and Paul H Ehrlich and Anne H Ehrlich. Paul Paddock and William Paddock even advocated the application of the 'triage' principle in the selection of countries which should and should not be saved from starvation through American assistance. India was listed in such an analysis as a nation which can never feed itself.

The introduction of Mexican semi-dwarf varieties of wheat in India in the early 1960s helped not only to improve wheat production, but also led to the union of brain and brawn in rural areas. The enthusiasm generated by the new technology can be glimpsed in the following extract from an article I had written in the Illustrated Weekly of India in 1969:

Brimming with enthusiasm, hard-working, skilled and determined, the Punjab farmer has been the backbone of the revolution. Revolutions are usually associated with the young, but in this revolution, age has been no obstacle to participation. Farmers, young and old, educated and uneducated, have easily taken to the new agronomy. It has been heart-warming to see young college graduates, retired officials, ex-armymen, illiterate *peasants and small farmers queuing up to get the new seeds. At least in the Punjab, the divorce between intellect and labour, which has been the bane of our agriculture, is vanishing.*

Nippon Foundation was established in 1962 by late Ryoichi Sasakawa, a statesman and businessman. This foundation focuses on social welfare, public health and education along with other activities. Yohei Sasakawa, his son is the current chairman of this foundation.

Borlaug's Working Principle

The five principles Borlaug adopted, in his life, to quote his own words, were

- Give your best.
- Believe you can succeed.
- Face adversity squarely.
- Be confident, you will find the answers when problems arise.
- Then go out and win some bouts.

These principles have shaped the attitude and action of thousands of young farm scientists across the world. He applied these principles in the field of science and agricultural development, but I guess he developed them much earlier in the field of wrestling, judging from his induction into the Iowa Wrestling Hall of Fame in 2004.

Role of Borlaug in Determining the Future of Agriculture

Having made a significant contribution to shaping the agricultural destiny of many countries in Asia and Latin America, Borlaug turned his attention to Africa in 1985. With support from President Jimmy Carter, the late Ryoichi Sasakawa, Yohei Sasakawa and the Nippon Foundation, he organized the Sasakawa Global 2000 programme. Numerous small-scale farmers were helped to double and triple the yield of maize, rice, sorghum, millet, wheat, cassava and grain legumes. Unfortunately, such spectacular results in demonstration plots did not lead to significant production gains at the national level, due to lack of infrastructure such as irrigation, roads, seed production and remunerative marketing systems. This made him exclaim, "Africa has the potential for a green revolution, but you cannot eat potential". The blend of professional skill, political action and farmers'

Sasakawa Global 2000 is the country programs of the Sasakawa Africa Association (SAA). SAA work in close collaboration with national agricultural extension services across sub-Saharan Africa.

World Food Prize was conceived by Nobel Peace Prize Laureate Norman Borlaug in 1985. This prize emphasizes the importance of sustainable food supply for every individual.

enthusiasm needed to ignite another green revolution as in India was lacking in Africa at that time.

Concerned with the lack of adequate recognition for the contributions of farm and food scientists, he had the World Food Prize established in 1986, which he hoped would come to be regarded as the Nobel Prize for food and agriculture. Throughout his professional career, Borlaug spent time in training young scholars and researchers. This led him to promote the World Food Prize Youth Institute and its programme to help high school students' work in other countries in order to widen their understanding of the human condition. This usually became a life-changing experience for them.

When Mahatma Gandhi died in January 1948, the then Prime Minister of India, Jawaharlal Nehru said, "The light has gone out of our life, but the light that shone in this country was no ordinary light. A thousand years later, that light will be seen in this country, the world will see it, and it will give solace to innumerable hearts. For that light represented the living, eternal truth, reminding us of the right path, drawing us from error, taking humankind to freedom from hunger and deprivation". The same can be said of Norman Borlaug. His repeated message that there was no time to relax until hunger became history will be heard as long as a single person is denied opportunity for a healthy and productive life because of malnutrition.

Norman Borlaug was a remarkable man who was supported by a remarkable family – wife Margaret, son William and daughter Jeanie and lovely grandchildren. His wife Margaret who died in 2007, to my mind, is the unsung heroine of the green revolution. Without her unwavering support, Borlaug might not have accomplished so much in his long and demanding career.

Borlaug was not only a great scientist but also a humanist full of compassion and love for fellow human beings, irrespective of race, religion, color or political belief. This is clear from his last spoken words on the night of Saturday, 12 September 2009.

Earlier in the day, a scientist had shown him a nitrogen tracer developed for measuring soil fertility. His last words were: "Take the tracer to the farmer". This life-long dedication to taking scientific innovation to farmers without delay set Borlaug apart from most other farm scientists carrying out equally important research.

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Acknowledgement

This article draws partly from an Obituary I had written for *Nature* (Vol 461, 15 October 2009).